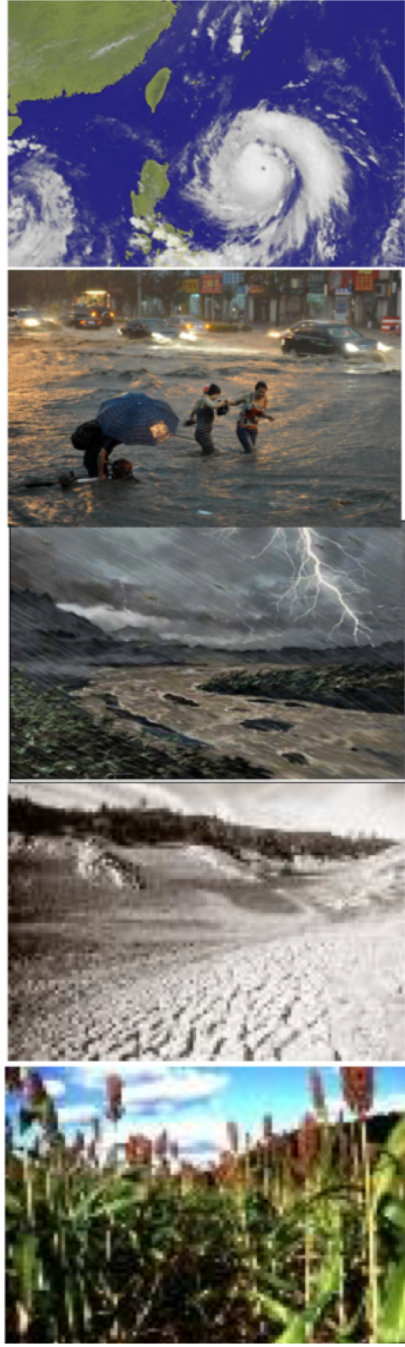
Satellite Programs for Earth Science and Applications from Space in China



National Earth Observation Satellite System of China

- **Operational missions:**
  CSIC: Civil Space Infrastructure of China (2015-2025)

- **Research and technology verification missions**
  TANSAT
  High resolution earth observation system (GF series, 2006-2020)

CSIC: Civil Space Infrastructure of China (2015-2025)

- **EO satellite program:**
  - **3 series:** Land, ocean and atmosphere
- **7 constellations**
  - High resolution optical imaging constellation
  - Mid-resolution optical constellation
  - SAR constellation (LEO & GEO)
  - Water color constellation
  - Ocean dynamic constellation
  - LEO meteorological constellation
  - GEO meteorological constellation
- **3 specific satellite series**
  - Ocean environment surveillance satellite (SAR and GEO)
  - Physical field satellite
  - Atmospheric composition satellite

Meteorological Satellite Series (FY-series)

- **FY=Feng Yun 风云=wind and cloud**
- **Operated by National Satellite Meteorological Center, China Meteorological Administration (NSMC, CMA)**
- **Two constellations:**
  - LEO (FY-1, 3… series)
  - GEO (FY-2, 4… series)
- **Specific satellites**
  - Atmospheric composition

FY-series overview

FengYun Meteorological Satellites

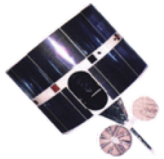
Polar System (LEO)

First Generation
FY-1 A, B, C, D

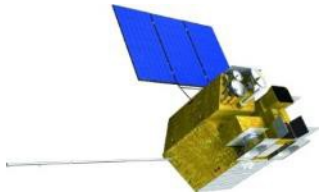
Second Generation
FY-3 A, B, C, D, E, F, G

Expected until 2025

Geostationary System (GEO)



First Generation
FY-2 A, B, C, D, E, F, G, H



Second Generation
FY-4 A, B, C, D, E

Expected until 2030

Launched Satellites

Since Jan. 1969, China began to develop his own meteorological Satellite				
Leo	Launch Data		Geo	Launch Data
FY-1A	Sept. 7, 1988		FY-2A	Jun. 10, 1997
FY-1B	Sept. 3, 1990		FY-2B	Jun. 25, 2000
FY-1C	May 10, 1999		FY-2C	Oct. 18, 2004
FY-1D	May 15, 2002		FY-2D	Dec. 8, 2006
FY-3A	May 27, 2008		FY-2E	Dec. 23, 2008
FY-3B	Nov 5, 2010		FY-2F	Jan. 13, 2012
FY-3C	Sept 23, 2013		FY-2G	Dec. 31, 2014
FY-3D	Nov 15, 2017		FY-4A	Dec. 11, 2016

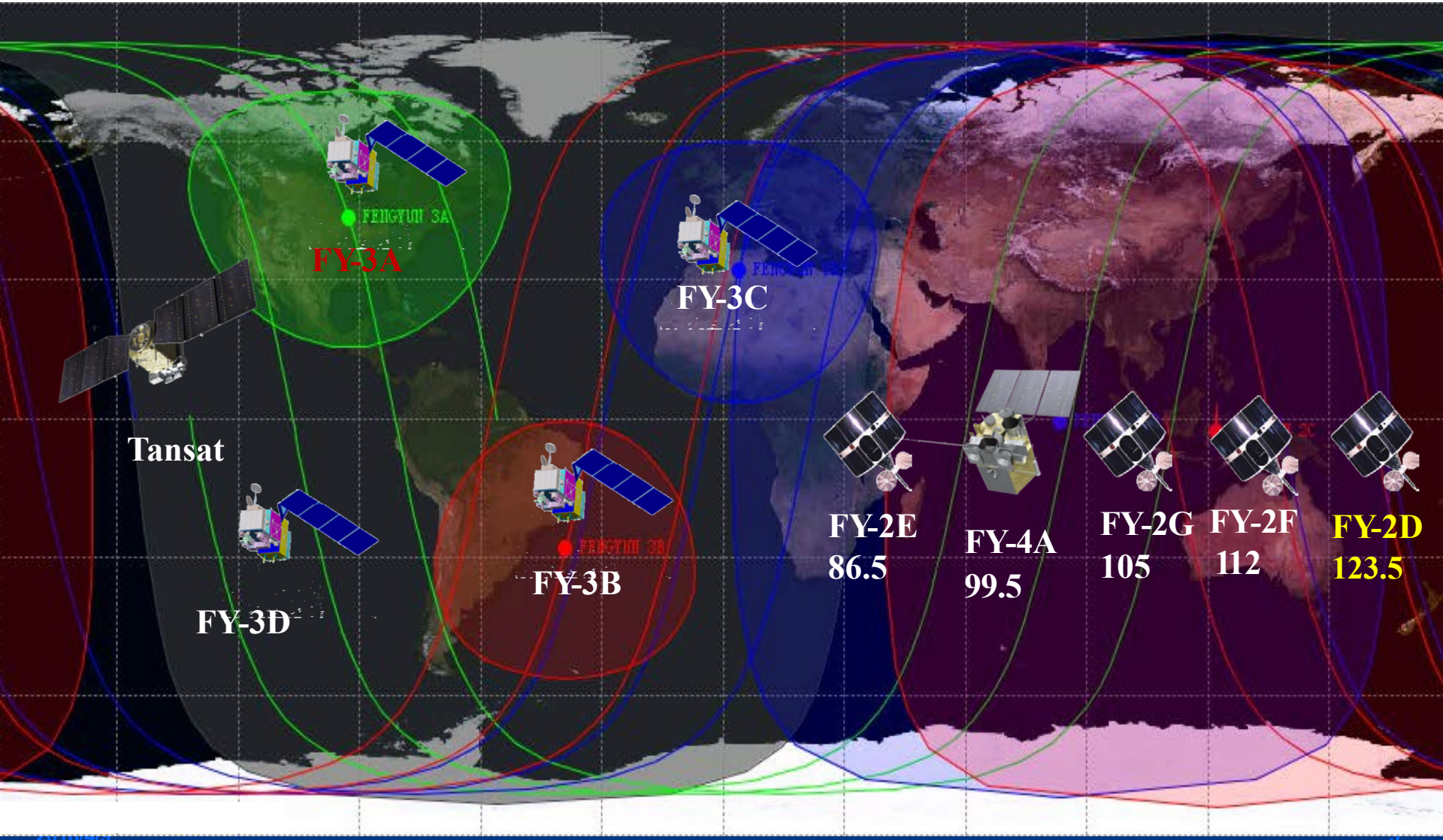
Before 2000s: emphasizing on development of the satellite

2000 – 2010 : emphasizing the transition from R&D to operational

After 2010s : emphasizing the data/service quality improvement and calibration/validation for the operational satellites

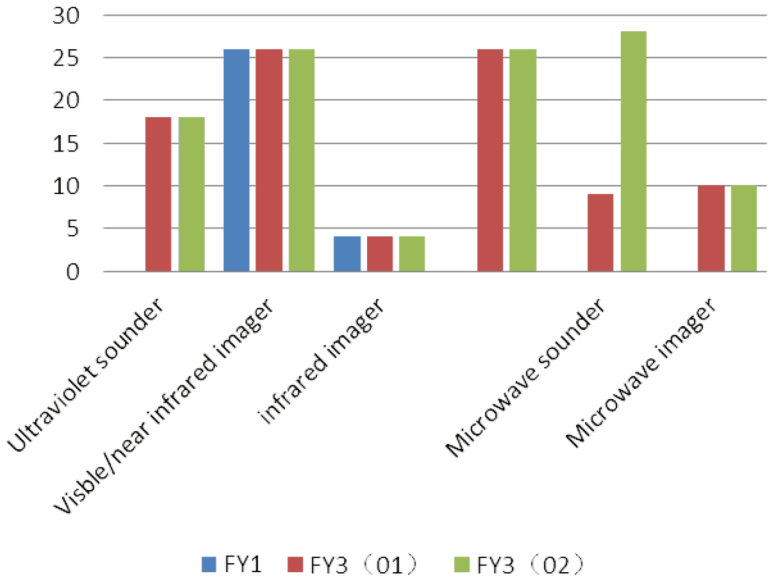
Current missions

FY Program: 10 in orbit, 8 in operation



Payloads/Instruments

Satellite		Payload Name
FY-1	FY-1 A/B	5-channel VIRR
	FY-1 C/D	10-channel VIRR
FY-2	FY-2 A/B	3-channel VISSR
	FY-2 C/D/E	5-channel VISSR
FY-3	FY-3 A/B	10-channel VIRR
		MERSI
		IRAS
		MWTS
		MWHS
		MWRI
		SBUS
		TOU
		ERM
		SIM
	FY-3C	GNOSS
FY-4	FY-4A	AGRI
		GIIRS
		LMI



Optical Imager

Atmospheric Sounder

Microwave Imager

Atmospheric Composition

Radiation Budget

FY-GEO

- **In operation**

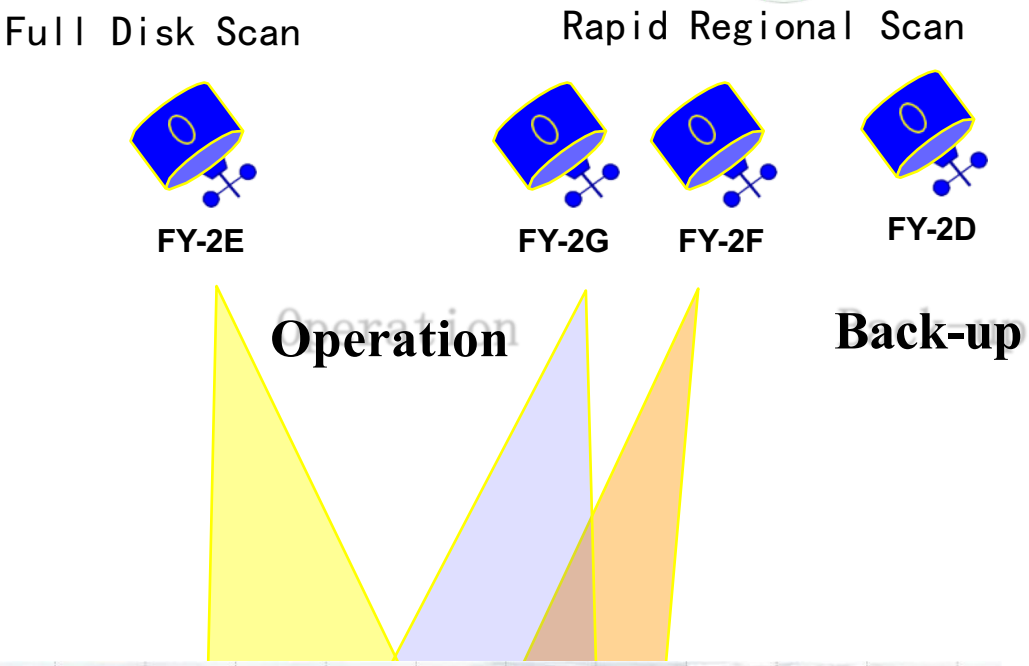
FY-2G: Full Disk (105° E)

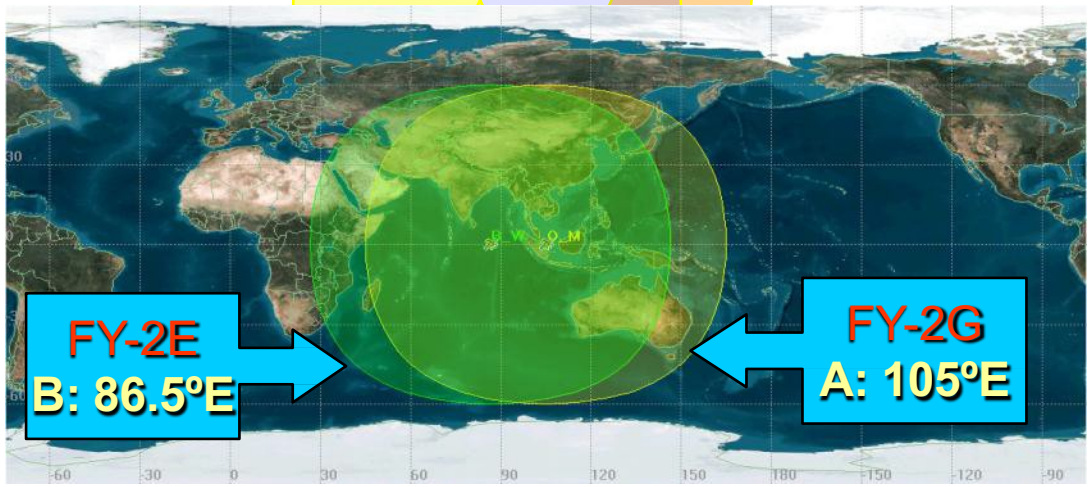
FY-2E: Full Disk (86.5° E)

FY-2F: Regional (112° E)

- **Back-up**

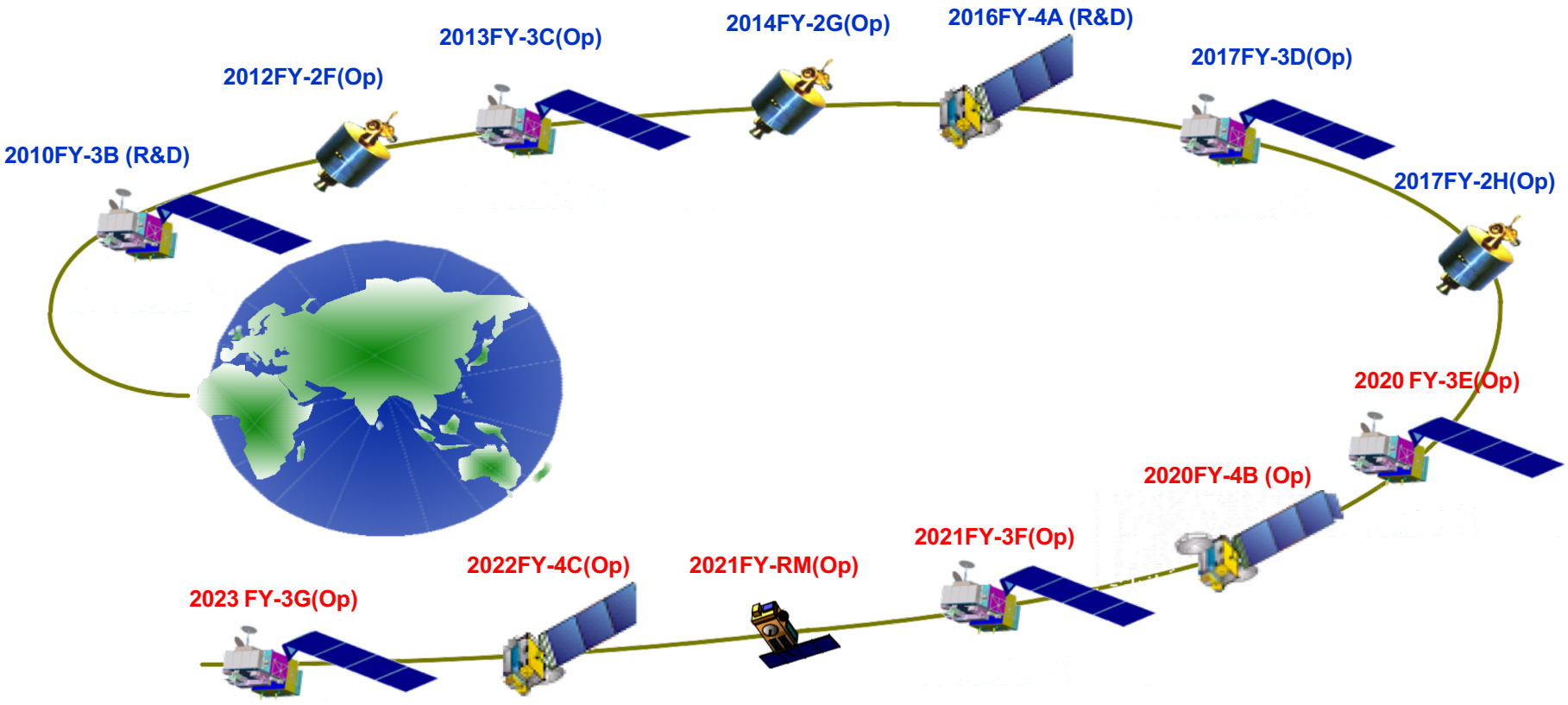
FY-2D (123.5° E)





Future Programs

National Program for Fengyun Meteorological Satellite 2011-2025



- 7 more satellites will be launched

Oceanographic Satellite Series (HY-series)

- **HY=Hai Yang 海洋=Ocean**
- **Operated by National Satellite Ocean Application Service, State Oceanic Administration of China (NSOAS, SOA)**
- **Two constellations:**
  - Ocean color (HY-1 series)
  - Ocean dynamic environment (HY-2series)
- **Specific satellites**
  - Ocean environment monitoring and surveillance satellites
  - Ocean salinity satellite

HY-series overview

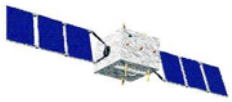
HY ocean Satellites (2 constellations)

Ocean color constellation

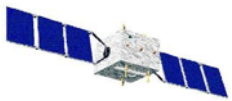
HY-1 series

1st Series
HY-1A,B

2nd Series
HY-1C,D



New Generation Series
HY-1E, F

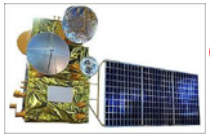


Expected until 2025

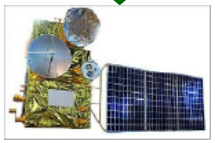
Ocean Dynamic Constellation

HY-2 series

Polar orbit
HY-2A,B,E



Inclined orbit
HY-2C,D,F,G

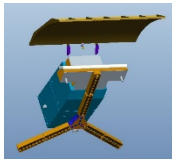


HY-2 Next Generation
HY-2H

Wind and wave series

CFOSAT

Ocean Salinity Mission



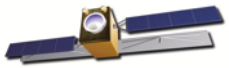
Expected until 2025

HY-series overview

Ocean monitoring and surveillance

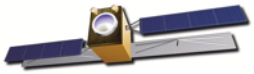
LEO SAR satellite

GF-3



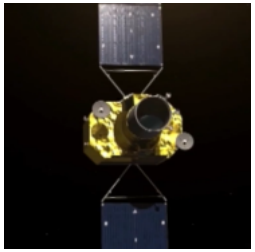
HY-3 series

HY-3A, B, C



GEO

GEO ocean color



GEO SAR

Expected until 2025

Expected until 2025

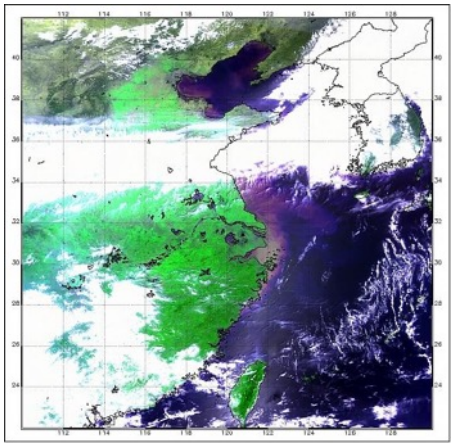
Launched Satellites

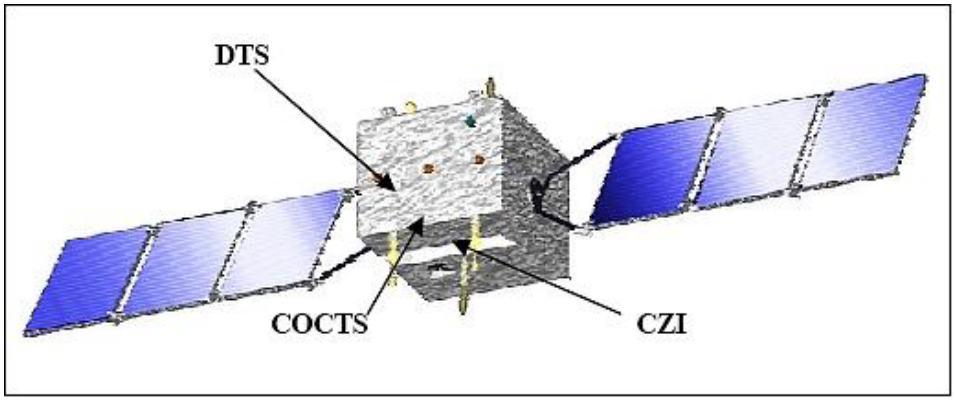
From 2011, China launched 4 ocean satellites				
Ocean Color	Launch Data		HY-2 Series	Launch Data
HY-1A	May 15, 2002 (operation ended)		HY-2A	August 15, 2011
HY-1B	April 11, 2007		HY-2B	October 25, 2018
HY-1C	September 7, 2018		CFOSAT	October 29, 2018

HY-1A/B Payloads/Instruments

COCTS
(Chinese Ocean Color and Temperature Scanner)
-medium-resolution optical imager

CZI
(Coastal Zone Imager)
-multispectral pushbroom CCD imager





- **HY-1C & HY-1D**
  - The successor mission to HY-1B
  - A constellation of two satellites observing oceans in the morning and afternoon, respectively

Sensors	Notes
Chinese Ocean Color and Temperature Scanner	Ten bands, the swath is 1.6 times larger than that of HY-1B
Coastal Zone Imager	Four bands. The resolution is improved from 250m of HY-1B to 50m
Ultra violet Imaging and onboard calibration sensor	A new sensor with 2 UV bands

  - HY-1C launched in 2018

Sensors onboard HY-1C/D satellites

1. Ocean Color and Temperature Scanner

- swath >=2900km; spatial resolution: 1100m
- 10 bands, 0.402-12.5μm

2. Coastal Zone Imager

- swath >=950km; spatial resolution: 50m
- 4 bands, 0.42-0.89μm

3. Ultraviolet Imager

- swath >=2900km; spatial resolution: 550m
- 2 bands, 0.355-0.865μm

4. On-board Calibration Spectrometer

- 10 calibration bands
- spatial resolution: 550m(ultraviolet bands); 1100m(visible and near infrared bands)

Number	Wavelengths(μm)
1	0.402-0.422
2	0.433-0.453
3	0.480-0.500
4	0.510-0.530
5	0.555-0.575
6	0.660-0.680
7	0.730-0.770
8	0.845-0.885
9	10.3-11.3
10	11.5-12.5

HY-2A/B Payloads/Instruments

- DFRA: Dual-frequency (Ku, C) radar altimeter and a 3-channel calibration radiometer;
- SCAT: Scanning radar scatterometer (Ku-band, 13.256GHz);
- MWRI: Multiple-channel microwave imager (6.6-37GHz)
- ACMR: Tri-frequency nadir looking microwave radiometer (19.35/23.8/37GHz)

HY-2C/D Payloads/Instruments

- DFRA: Dual-frequency (Ku, C) radar altimeter and a 3-channel calibration radiometer;
- SCAT: Scanning radar scatterometer (Ku-band, 13.256GHz);
- ACMR: Tri-frequency nadir looking microwave radiometer (19.35/23.8/37GHz)

CFOSAT and future wind/wave missions

Orbit: near-polar , sun synchroneous

Local time at descending node AM 7:00

Altitude at the equator 519 km

Cycle duration 13 days

Follow-on (next generation/ Payload upgrade

HY-2

- **Radar altimeter: swath and precision**
  - Wide Swath Interferometric Radar Altimeter
  - Nadir-looking Synthetic Aperture Radar Altimeter
- **Radar Scatterometer: high wind and all-weather**
  - Ku-C dual frequency polarized scatterometer
- **Radiometric Imager:**
  - Full-polarimetric microwave imager

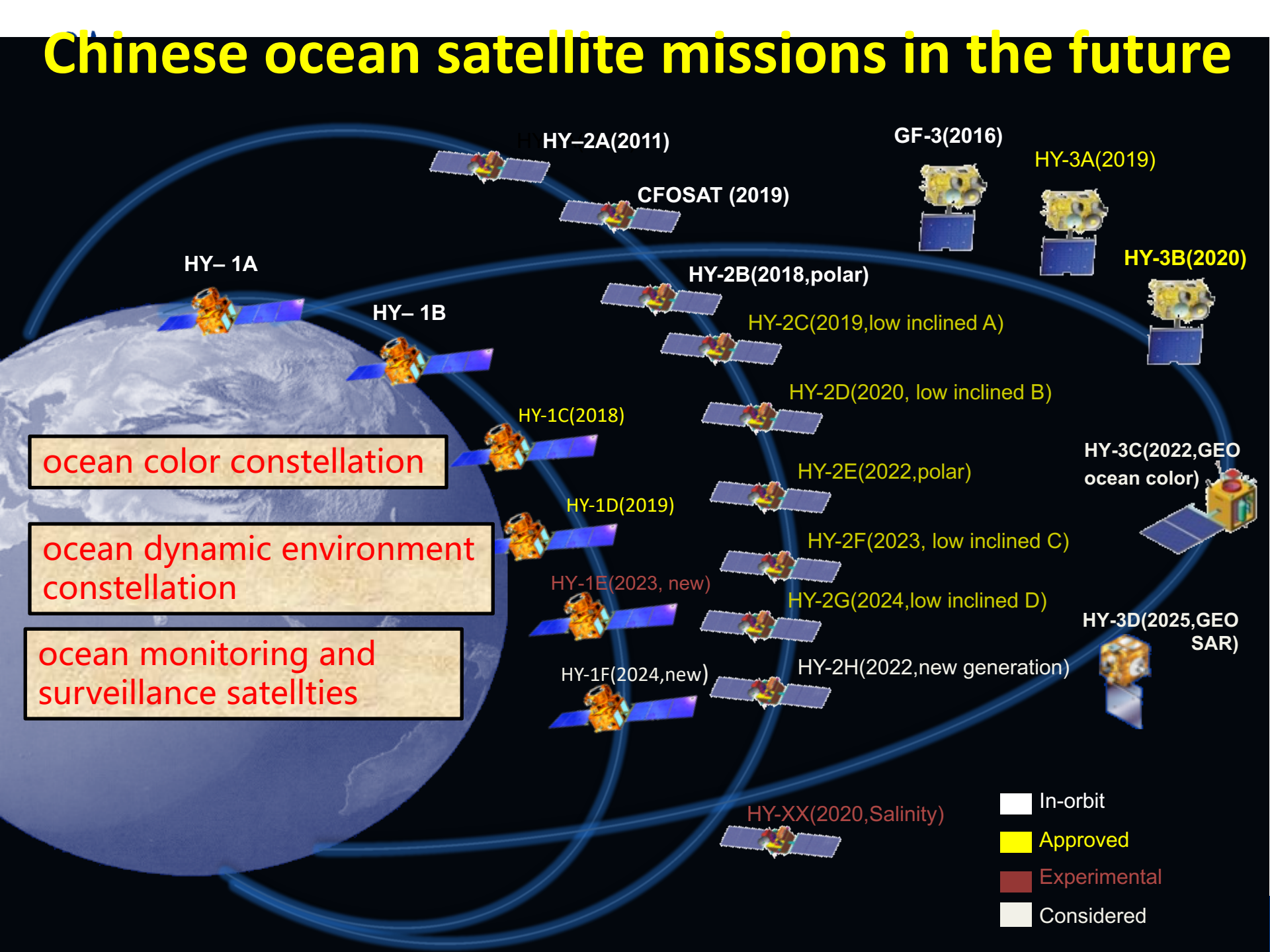
CFOSAT==》wind and wave missions

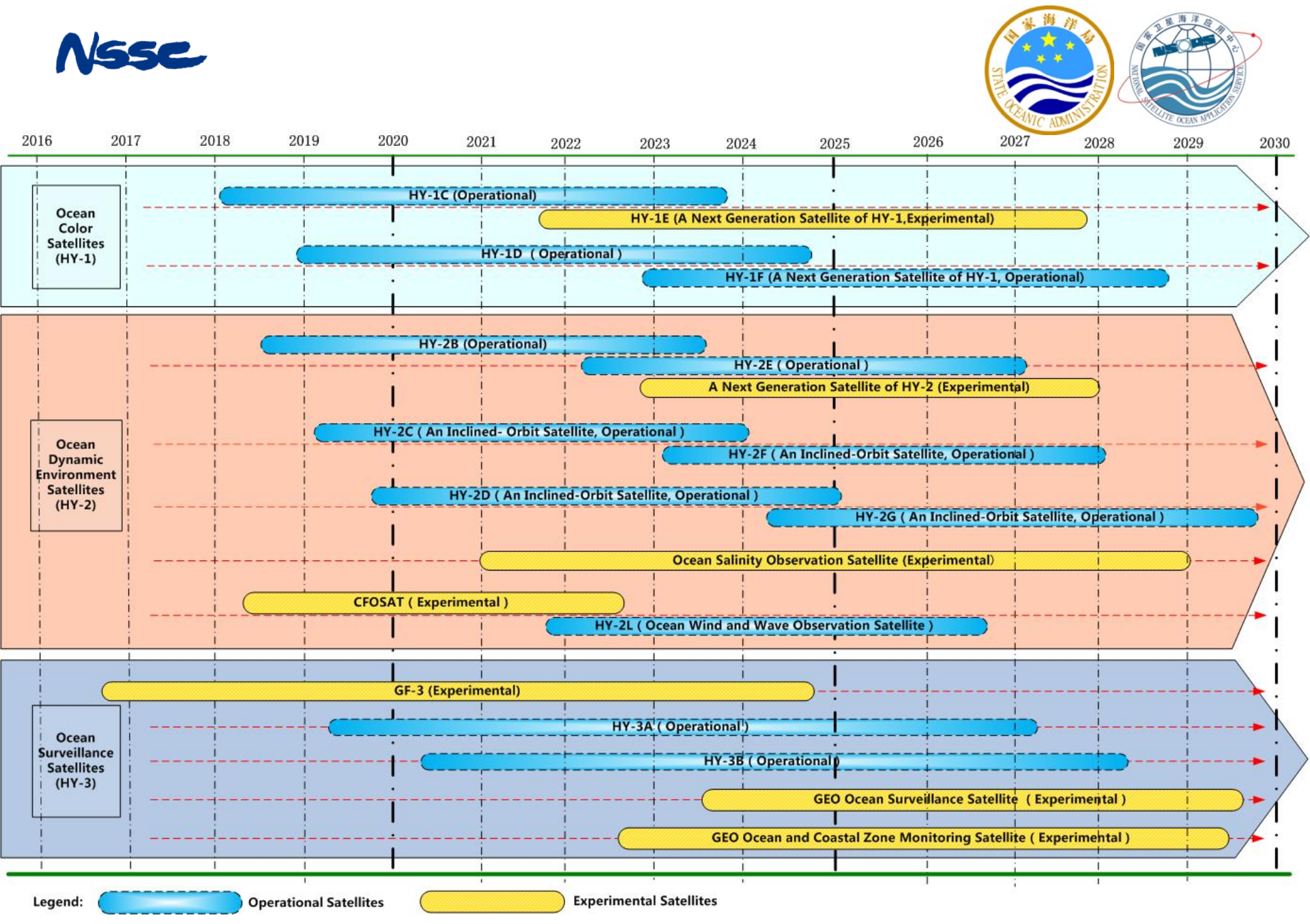
- **Radar scatterometer: ocean current capability**
  - Doppler scatterometer
  - Ku-Ka dual-frequency for higher resolutions

HY-2 Follow-On Pathfinder Mission: Tiangong-2 Interferometric Imaging Radar Altimeter

- **Interferometric Imaging Radar Altimeter (InIRA)**
  - Ku-band (13.58GHz) wide swath inteferometric radaer altimeter
  - Flown on Chinese Tiangong-2 space laboratory
  - Launched on September 15, 2016
- **Objectives:**
  - wide-swath sea surface height at mesoscale and sub-mesoscale, sea waves and sea winds.
  - Inland waters, e.g., lakes and rivers, coasts.

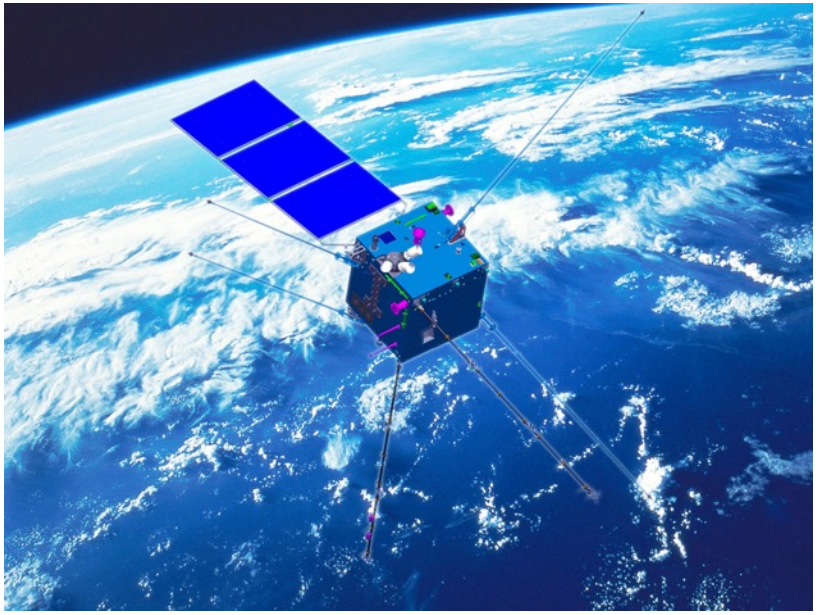
Chinese ocean satellite missions in the future




2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Ocean Color Satellites (HY-1)
HY-1C (Operational)
HY-1E (A Next Generation Satellite of HY-1,Experimental)
HY-1D (Operational)
HY-1F (A Next Generation Satellite of HY-1, Operational)
Ocean Dynamic Environment Satellites (HY-2)
HY-2B (Operational)
HY-2E (Operational)
A Next Generation Satellite of HY-2 (Experimental)
HY-2C (An Inclined- Orbit Satellite, Operational)
HY-2F (An Inclined-Orbit Satellite, Operational)
HY-2D (An Inclined-Orbit Satellite, Operational)
HY-2G (An Inclined-Orbit Satellite, Operational)
Ocean Salinity Observation Satellite (Experimental)
CFOSAT (Experimental)
HY-2L (Ocean Wind and Wave Observation Satellite)
Ocean Surveillance Satellites (HY-3)
GF-3 (Experimental)
HY-3A (Operational)
HY-3B (Operational)
GEO Ocean Surveillance Satellite (Experimental)
GEO Ocean and Coastal Zone Monitoring Satellite (Experimental)
Legend:
Operational Satellites
Experimental Satellites

China Seismo-Electromagnetism Satellite mission

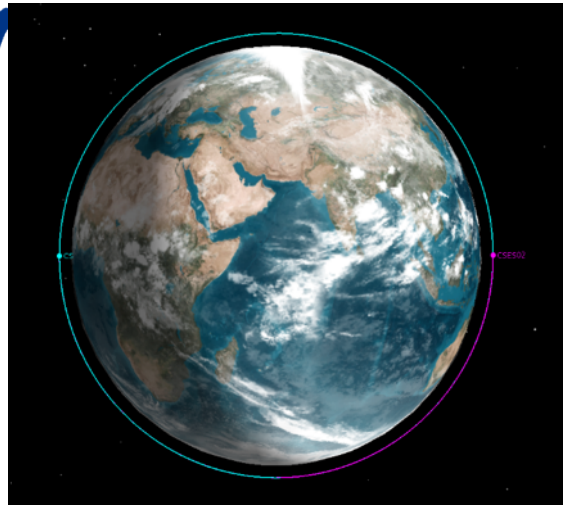
- **CSES-1/ZH-1(ZhangHeng-1):**
  - Joint Sponsored by China National Space Administration and China Earthquake Administration, with partly collaboration with Italian Space Agency and Austria Space Institute
  - 1st Satellite of the Geophysical Fields Monitoring Satellite Mission in CSIP
  - Launched on Feb 02, 2018
- **Operated by :**
  - Center for Earthquake Observation from Space, China Earthquake Administration

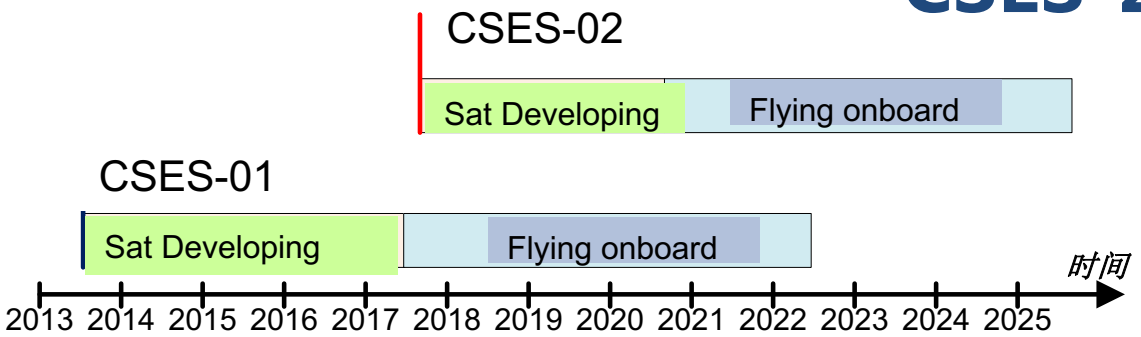


Scientific Payloads

Contributors	Payloads	Functions
Beijing Univ. of Aerospace and Astronauts	Search-Coil Magnetometer	Measuring the magnetic field and electric field
National Space Science Center, CAS & Austrian Space Institute	High Precision Magnetometer	
China Academy of Space Technology	Electric field detector	
National Space Science Center, CAS	Plasma analyzer	Measuring the in-situ disturbance of plasma in ionosphere
National Space Science Center, CAS	Langmuir probe	
China Academy of Space Technology	GNSS Occultation Receiver	Measuring the profile disturbance of plasma in ionosphere
Institute of Electrical Wave Propagation of China	Three frequency transmitter	
Italian National Institute of Nuclear Physics Institute of High Energy Physics, CAS	Energetic particle detector	Measuring the flux and spectrum of energetic particles

CSES-2





CSES-02 proved in 2015 and passed the feasibility review in the end of Sept. 2017

- Same orbit with CSES-01 with 180 degree span
- 6 same payloads, 2 modifying payloads and 1 more payloads
- Due to launch in 2020

CSES-02 Scientific Payloads

Institutions on Duty	Payloads	Description
Beijing Univ. of Aerospace and Astronauts	Search-Coil Magnetometer	Measuring the magnetic field and electric field
National Space Science Center, CAS Austria Space Institute	High Precision Magnetometer(double CPT and Fluxgate sensors)	
China Academy of Space Technology & Italian National Institute of Nuclear Physics	Electric field detector	
National Space Science Center, CAS	Plasma analyzer	Measuring the in-situ disturbance of plasma in ionosphere
	Langmuir probe	
China Academy of Space Technology	GNSS Occultation Receiver	Measuring the profile disturbance of plasma in ionosphere
Research Institute of Radio Wave Propagation of China	Three frequency transmitter	
National Space Science Center, CAS	Ionospheric Photometer	
Italian National Institute of Nuclear Physics; Institute of High Energy Physics, CAS	Energetic particle detector	Measuring the flux and spectrum of energetic particles

Research Program

- **Technology demonstration missions**
  - TanSAT (MOST mission)
  - GF series (CNSA missions) (GF=high-resolution)

    CHEOS: China High-definition Earth Observation System

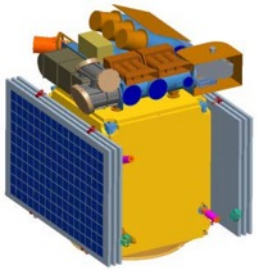
TANSAT

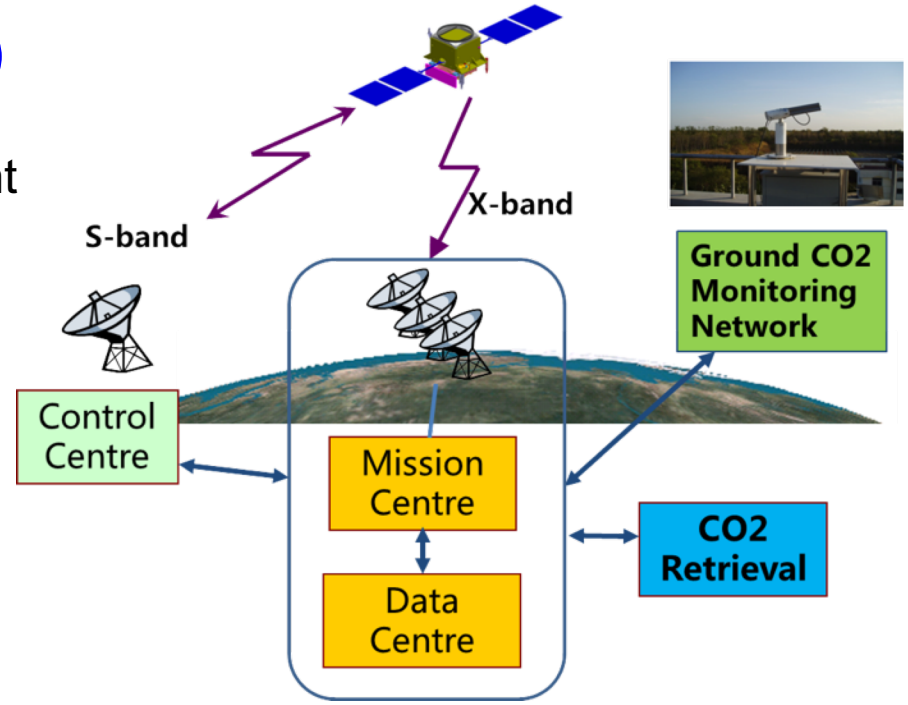
Mission objectives:

To acquire global atmospheric column-averaged CO2 dry air mole fraction

Satellite and Payloads (CAS)

1) CO2 spectrometer
2) Cloud and Aerosol Polarize Instrument (CAPI)





TANSAT Ground segment by CMA

TANSAT: Launched on 22 Dec, 2016

GF series (2006-2020)

- **GF-1 (2013):**

2 multispectral cameras + 4 multispectral wide-field cameras

(2m-panchromatic, 8m-multispectral ； wide-swath mode: 16m@800km)

- **GF-2 (2014)**

2 high-resolution cameras

(0.81m-panchromatic, 3.24m-multispectral; swath 45 km)

- **GF-3 (2016)**

C-band SAR

(12 modes: high-resolution (1 m);large-swatch (650 km), co-and x-pol)

- **GF-4 (2015)**

GEO imager

(50m-visible, 400m-IR, 7000kmX7000km)

- **GF-5 (2018)**

Atmospheric composition

(visible and short-wave infra hyper-spectral camera, spectral imager, greenhouse gas detector, atmospheric environment infrared detector)